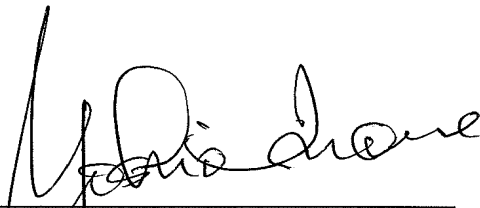


## DECLARATION

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hereby declare that I am the translator of the  
documents attached hereto and certify that to the  
best of my knowledge and belief the following is a  
true and correct translation of Application for  
patent, Specification, Drawings and Abstract of  
Japanese Patent Application No. 2004-019004 filed on  
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Signed this 23rd day of February, 2010.

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2004-019004

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2004-019004(January 27, 2004)

【Name of the Document】                      Scope of Claims

【Claim 1】

5            A telescopic shaft for vehicle steering that is assembled into a steering shaft for a vehicle and has a female shaft and a male shaft that are fitted relatively unrotatably but slidably, the telescopic shaft for vehicle steering comprising:

10           torque transmitting portions that are respectively disposed on an outer surface of the male shaft and on an inner surface of the female shaft and come in contact with each other for transmitting torque upon rotation; and

15           a preload portion composed of a rolling member that is disposed between the outer surface of the male shaft and the inner surface of the female shaft at a different position from a position where the torque transmitting portions are located and rolls when the male shaft and the female shaft relatively  
20           move in the axial direction and an elastic member that is disposed adjacent to the rolling member in the diametral direction and gives pressure upon the male shaft and the female shaft through the rolling member,

25           wherein when a gap in the torque transmitting portions is converted into a rotation angle A and a possible flexural amount of the elastic member in the

preload portion is converted into a rotation angle B,  
the rotation angle A is set to be less than the  
rotation angle B upon transmitting no torque.

【Claim 2】

5           The telescopic shaft for vehicle steering  
according to claim 1, wherein the rotation angle A at  
the torque transmitting portions is set from 0.01  
degrees to 0.25 degrees.

【Claim 3】

10           The telescopic shaft for vehicle steering  
according to claim 1, wherein the torque transmitting  
portions are composed of a projection elongated in  
the axial direction and having a substantially arc  
sectional shape formed on the outer surface of the  
15 male shaft and a groove elongated in the axial  
direction and having a substantially arc sectional  
shape formed on the inner surface of the female shaft.

【Claim 4】

20           The telescopic shaft for vehicle steering  
according to claim 1, wherein the torque transmitting  
portions do not come in contact with each other  
continuously in the axial direction upon transmitting  
no torque.

【Claim 5】

25           The telescopic shaft for vehicle steering  
according to claim 1, wherein the torque transmitting  
portions are composed of a spline-fitting structure

or a serration-fitting structure formed on the outer surface of the male shaft and the inner surface of the female shaft.

【Claim 6】

5           The telescopic shaft for vehicle steering according to claim 1, wherein the preload portion has a first axial groove disposed on the outer surface of the male shaft and a second axial groove disposed on the inner surface of the female shaft opposite to the  
10 first axial groove, and the rolling member and the elastic member are disposed between the first axial groove and the second axial groove.

【Claim 7】

          The telescopic shaft for vehicle steering  
15 according to claim 1, wherein a plurality of preload portions are disposed between the male shaft and the female shaft, and the plurality of transmitting portions are disposed between adjacent preload portions.

20           【Claim 8】

          The telescopic shaft for vehicle steering according to claim 7, wherein the preload portions are disposed in the circumferential direction with an interval of 180 degrees having the torque  
25 transmitting portions in-between.

【Claim 9】

          The telescopic shaft for vehicle steering

according to claim 7, wherein the preload portions are disposed in the circumferential direction with an interval of 120 degrees having the torque transmitting portions in-between.

5      **【Claim 10】**

          The telescopic shaft for vehicle steering according to claim 9, wherein the torque transmitting portions are disposed at the center in the circumferential direction between the preload  
10   portions.

**【Claim 11】**

          The telescopic shaft for vehicle steering according to claim 1, wherein the rolling member may include at least one spherical member.

15      **【Claim 12】**

          The telescopic shaft for vehicle steering according to claim 1, wherein the elastic member is composed of a leaf spring.

**【Claim 13】**

20      The telescopic shaft for vehicle steering according to claim 1, wherein a solid lubricant film is formed on the outer surface of the male shaft or the inner surface of the female shaft.

[Name of Document] Specification

[Title of The Invention]

TELESCOPIC SHAFT FOR VEHICLE STEERING

[Technical Field]

5 [0001]

The present invention relates to a telescopic shaft for vehicle steering.

[Background Art]

[0002]

10 In a steering mechanism for a vehicle, in order to absorb axial displacement occurred upon traveling and to prevent the displacement and vibrations from being transferred onto a steering wheel, a telescopic shaft constructed by a male shaft and a female shaft  
15 that are spline-fitted to each other has been used in a portion of a steering mechanism. The telescopic shaft is required to be able to reduce backlash noises from the spline portion, backlash on the steering wheel, and sliding friction upon sliding in  
20 the axial direction.

[0003]

In order to fill the requirements, the spline portion of a male shaft of a telescopic shaft is coated with nylon and a sliding portion thereof is  
25 applied by grease, thereby absorbing and reducing metallic noises, metallic knocking noises, and the like, as well as reducing sliding friction and



backlash in the rotational direction. In this case, processes for forming a nylon layer are such that cleaning a shaft, applying primer thereon, heating it, coating nylon powder, cutting coarsely, cutting  
5 finely, and selectively fitting into a female shaft. The final cutting process is carried out by selecting a die corresponding to an already processed female shaft.

[0004]

10 In Patent Document 1, there is disclosed a telescopic shaft for vehicle steering in which balls are disposed in a groove formed on outer periphery of an inner shaft and inner periphery of an outer shaft with an elastic member disposed between the groove of  
15 the inner shaft and the balls, when moving along an axial direction, a sliding load between a male shaft and a female shaft is reduced by rotating the balls and when rotating, torque is transmitted by restraining the balls. The aforementioned document  
20 discloses that in order to make it possible to transmit torque even if the ball is broken, a male groove and a female groove each having a cross-sectional combination with a certain play are formed on the inner shaft and the outer shaft, respectively.

25 [Patent Document 1]

Patent Application Laid-Open No. 2001-50293  
(pages 7 and 13, Fig. 12)

[Disclosure of The Invention]

[Problems To be solved by The Invention]

[0005]

However, in the former case, it is necessary to  
5 suppress backlash of the telescopic shaft to be  
minimum with suppressing the sliding load to be  
minimum, so that in the final cutting process, a die  
corresponding to a female shaft has to be selected  
among dies each having different over-pin diameter  
10 with an interval of few micrometers resulting in  
increase in processing cost. In addition, backlash in  
the rotational direction becomes large as progress in  
wearing the nylon layer according to the used time  
length.

15 [0006]

Moreover, with exposing to high temperature of  
the engine room, the nylon layer makes alteration in  
volume resulting in extreme increase in sliding  
friction and drastic acceleration of wear, so that  
20 backlash in the rotational direction becomes large.  
Accordingly, there has been a request to easily  
provide a telescopic shaft for vehicle steering  
capable of suppressing deterioration in steering  
feeling and generation of noises caused by backlash  
25 in the rotational direction for a long period with a  
low cost.

[0007]

In the Patent Document 1, which is the latter case, rotation of a plurality of balls provides telescopic movement and transmission of torque. Accordingly, since sufficient number of balls have to  
5 be disposed structurally to endure an input torque, there are structural defects such that it becomes difficult to be made compact as a telescopic shaft for vehicle steering, and it also becomes difficult to secure a sufficient collapse stroke upon collision.

10           [0008]

The present invention is made in view of aforementioned problems and has an object to provide a telescopic shaft for vehicle steering capable of realizing a stable sliding load, securely preventing  
15 backlash in the rotational direction, and transmitting torque under high rigidity.

[Means for solving the Problems]

[0009]

In order to accomplish the object, the present  
20 invention of claim 1 provides a telescopic shaft for vehicle steering that is assembled into a steering shaft for a vehicle and has a female shaft and a male shaft that are fitted relatively unrotatably but slidably, the telescopic shaft for vehicle steering  
25 includes

torque transmitting portions that are respectively disposed on an outer surface of the male

shaft and on an inner surface of the female shaft and come in contact with each other for transmitting torque upon rotation, and

5 a preload portion composed of a rolling member that is disposed between the outer surface of the male shaft and the inner surface of the female shaft at a different position from a position where the torque transmitting portions are located and rolls when the male shaft and the female shaft relatively  
10 move in the axial direction and an elastic member that is disposed adjacent to the rolling member in the diametral direction and gives pressure upon the male shaft and the female shaft through the rolling member,

15 wherein when a gap in the torque transmitting portions is converted into a rotation angle A and a possible flexural amount of the elastic member in the preload portion is converted into a rotation angle B, the rotation angle A is set to be less than the  
20 rotation angle B upon transmitting no torque.

[0010]

The telescopic shaft for vehicle steering according to claim 2, is characterized in that the rotation angle A in the torque transmitting portions  
25 is set from 0.01 degrees to 0.25 degrees.

[0011]

The telescopic shaft for vehicle steering

according to claim 3, is characterized in that the torque transmitting portions are composed of a projection elongated in the axial direction and having a substantially arc sectional shape formed on the outer surface of the male shaft and a groove  
5 elongated in the axial direction and having a substantially arc sectional shape formed on the inner surface of the female shaft.

[0012]

10 The telescopic shaft for vehicle steering according to claim 4, is characterized in that the torque transmitting portions do not come in contact with each other continuously in the axial direction upon transmitting no torque.

15 [0013]

The telescopic shaft for vehicle steering according to claim 5, is characterized in that the torque transmitting portions are composed of a spline-fitting structure or a serration-fitting  
20 structure formed on the outer surface of the male shaft and the inner surface of the female shaft.

[0014]

The telescopic shaft for vehicle steering according to claim 6, is characterized in that the  
25 preload portion has a first axial groove disposed on the outer surface of the male shaft and a second axial groove disposed on the inner surface of the

female shaft opposite to the first axial groove, and the rolling member and the elastic member are disposed between the first axial groove and the second axial groove.

5           [0015]

The telescopic shaft for vehicle steering according to claim 7, is characterized in that a plurality of preload portions are disposed between the male shaft and the female shaft, and a plurality of transmitting portions are disposed between adjacent preload portions.

          [0016]

The telescopic shaft for vehicle steering according to claim 8, is characterized in that the preload portions are disposed in the circumferential direction with an interval of 180 degrees having the torque transmitting portions in-between.

          [0017]

The telescopic shaft for vehicle steering according to claim 9, is characterized in that the preload portions are disposed in the circumferential direction with an interval of 120 degrees having the torque transmitting portions in-between.

          [0018]

25           The telescopic shaft for vehicle steering according to claim 10, is characterized in that the torque transmitting portions are disposed at the

center in the circumferential direction between the preload portions.

[0019]

The telescopic shaft for vehicle steering  
5 according to claim 11, is characterized in that the rolling member may include at least one spherical body.

[0020]

The telescopic shaft for vehicle steering  
10 according to claim 12, is characterized in that the elastic member is composed of a leaf spring.

[0021]

The telescopic shaft for vehicle steering  
according to claim 13, is characterized in that a  
15 solid lubricant film is formed on the outer surface of the male shaft or the inner surface of the female shaft.

[Effects of The Invention]

[0022]

20 As described above, according to the present invention, when a gap in the torque transmitting portions is converted into a rotation angle A and a possible flexural amount of the elastic member in the preload portion is converted into a  
25 rotation angle B, the rotation angle A is set to be less than the rotation angle B upon transmitting no torque. Accordingly, when high

torque is transmitted, the torque transmitting portions transmitting primary torque can come into contact with each other securely earlier than the preload portion transmitting lower torque to remove backlash. As a result, it becomes possible to prevent an excessive load from applying on the preload portion, so that backlash in the rotational direction can be prevented and torque can be transmitted with high rigidity over an extended time period.

[Most Preferred Mode For Carrying out The Invention]

[0023]

A telescopic shaft for vehicle steering according to an embodiment of the present invention will be described below with reference to the accompanying drawings.

[0024]

Fig. 1 is a side view showing a steering mechanism of a vehicle applied a telescopic shaft for vehicle steering according to an embodiment of the present invention.

[0025]

In Fig. 1, a steering apparatus is composed of an upper steering shaft 120 (including a steering column 103, and a steering shaft 104 rotatably supported by the steering column 103) fixed to a



member 100 of a vehicle through an upper bracket 101 and a lower bracket 102, a steering wheel 105 fixed to an upper end of the steering shaft 104, a lower steering shaft 107 connected to a lower end of the steering shaft 104 through a universal joint 106, a pinion shaft 109 connected to the lower steering shaft 107 through a steering shaft joint 108, and a steering rack 112 connected to the pinion shaft 109 and fixed to another frame 110 of the vehicle through an elastic member 111.

[0026]

In this construction, a telescopic shaft for vehicle steering (hereinafter shown as a telescopic shaft) according an embodiment of the present invention is used in the upper steering shaft 120 and the lower steering shaft 107. The lower steering shaft 107 is constructed by fitting a male shaft and a female shaft with each other. Such lower steering shaft 107 is required to have a function absorbing axial displacement generated upon driving a vehicle and not transmitting the displacement or vibrations to the steering wheel 105. Such function is required when the body has a sub-frame structure, and the solid member 100 on which the upper portion of the steering apparatus is fixed and the frame 110 on which the steering rack 112 is fixed are separate structures and press-fitted each other through an

elastic member 111 such as rubber. Moreover, there is a case where the telescopic function is required such as when the steering shaft joint 108 is fixed to the pinion shaft 109, the telescopic shaft is temporarily retracted in order to fit in and fix the pinion shaft 109. Furthermore, the upper steering shaft 120 is constructed by fitting a male shaft and a female shaft with each other. Such upper steering shaft 120 is required to have a telescopic function that in order for a driver to obtain an optimum driving position, the portion of the steering wheel 105 can be moved in the axial direction to be adjusted the position. In all cases described above, the telescopic shaft is required to have a function to reduce backlash noises generated from a fitting portion, backlash on the steering wheel 105 and sliding friction upon sliding in the axial direction.

[0027]

(FIRST EMBODIMENT)

Fig. 2 is a vertical cross-sectional view showing a telescopic shaft for vehicle steering according to a first embodiment of the present invention.

[0028]

Fig. 3 is a partial sectional view along a III-III line in Fig. 2.

[0029]

Fig. 4 is a graph showing a relation between torque and a rotation angle of the telescopic shaft for vehicle steering according to the first embodiment of the present invention.

5           [0030]

As shown in Figs. 2 and 3, a telescopic shaft for vehicle steering (hereinafter called a telescopic shaft) is composed of a male shaft 1 and a female shaft 2 disposed and fitted unrotatably but slidably with each other.

10           [0031]

In the first embodiment, although only a portion is shown in Fig. 3, a plurality of elongated projections 4 extending in the axial direction are formed on the outer surface of the male shaft 1. Although each of the axially elongated projections 4 is a male portion of a spline fitting, it may be a male portion of a serration fitting or simply a portion for a protuberance-concavity fitting.

15           [0032]

On the inner surface of the female shaft 2 at respective positions opposite to respective projections 4 on the male shaft 1, there are formed a plurality of grooves 6 extending in the axial direction. Although each of these axial grooves 6 is a female portion of a spline fitting, it may be a female portion of a serration fitting or simply a

portion for a protuberance-concavity fitting.

[0033]

Although only a portion is shown in Fig. 3, a plurality of grooves 3 extending in the axial direction are formed on the outer surface of the male shaft 1. On the inner surface of the female shaft 2 at respective positions opposite to them, a plurality of grooves 5 extending in the axial direction are formed. The axial grooves 3 and the axial grooves 5 are preferably disposed at regular intervals in the circumferential direction.

[0034]

Between the axial groove 3 on the male shaft 1 and the axial groove 5 on the female shaft 2, there are rotatably disposed a plurality of rigid spherical members 7 which are rolling members or balls and rotate upon relatively sliding of the shafts 1 and 2 in the axial direction. The axial groove 5 on the female shaft 2 takes a substantially arc shape or a Gothic arch shape in section.

[0035]

The axial groove 3 on the male shaft 1 is composed of a pair of slanted planer sides 3a, and a bottom 3b formed planer between the planer sides 3a.

[0036]

Between the axial groove 3 on the male shaft 1 and the spherical member 7, there is disposed an

elastic member 8 which is in contact with the spherical member 7 to apply a preload.

[0037]

The elastic member 8 has spherical member side  
5 contact portions 8a for coming in contact with the spherical member 7 at two points, groove side contact portions 8b that are separated from the spherical member side contact points 8a with given intervals in the circumferential direction respectively and come  
10 in contact with the respective planer sides 3a of the axial groove 3 on the male shaft 1, spring portions 8c that elastically apply pressure to respective spherical member side contact portions 8a and respective groove side contact portions 8b in a  
15 direction separating from each other, and a bottom portion 8d that is opposite to the bottom 3b of the axial groove 3.

[0038]

Each spring portion 8c has a substantially U-  
20 shape with a bending portion having a substantially arc shape. The spring portion 8c having such a bending shape makes it possible to elastically apply pressure to separate the spherical member contact portion p from the groove side contact portion 8b.

25 [0039]

On an end of the male shaft 1 where the male shaft 1 is inserted into the female shaft 2, a

stopper plate 9 for stopping and fixing the elastic member 8 in the axial direction is fixed to the male shaft 1 by plastically deforming a clinching or caulking portion 10. The stopper plate 9 also plays a  
5 roll to prevent the rolling member 7 from coming off from the axial groove 3 of the male shaft 1. In this manner, the telescopic shaft for vehicle steering according to the embodiment is constructed.

[0040]

10 In the telescopic shaft described above, upon rotation, in other words, upon transmitting higher torque the axially elongated projection 4 and the axial groove 6 come in contact with each other to form torque transmitting portions, while the axially  
15 elongated projection 4 and the axial groove 6 are constructed not to come in contact with each other upon transmitting no torque as described later.

[0041]

20 Since the telescopic shaft according to the embodiment of the present invention is constructed as described above, the male shaft 1 and the female shaft 2 are in contact with each other at torque transmitting portions by the existence of preload always slidably, so that upon moving relatively in  
25 the axial direction the male shaft 1 and the female shaft 2 slide with each other and the rolling member 7 can be rotated.

[0042]

Even if the axially elongated projection 4 formed on the male shaft is formed on the female shaft and the axial groove 6 formed on the female shaft is formed on the male shaft, the similar action and effect as the present embodiment can be obtained. It may be possible that the curvature of the axial groove 5 is made to be different from that of the rolling member 7 to come into point contact with each other. The rolling member 7 may be a spherical member. Moreover, the elastic member 8 may be a leaf spring. Furthermore, by applying grease on the sliding surface and rolling surface, a further lower sliding load can be obtained.

15 [0043]

The telescopic shaft according the present embodiment as described above is superior to the conventional one in the aspects described below.

[0044]

20 When the sliding surface is purely effected by sliding as in a prior art, a preload for preventing backlash has had to be kept within a certain extent. A sliding load is derived from a friction coefficient multiplied by a preload. Accordingly, when a preload is increased in hope of preventing backlash and increasing stiffness of the telescopic shaft, it causes a vicious circle of increasing the sliding

25

load.

【0045】

In that respect according to the present embodiment, since a preload portion adopts a rolling  
5 mechanism of the rolling members 7 upon relative movement in the axial direction, a preload can be increased without excessively increasing sliding load. Accordingly, preventing backlash and increasing stiffness can be accomplished without increasing a  
10 sliding load, which has never been accomplished by any prior arts.

【0046】

Upon transmitting high torque, the axially elongated projection 4 and the axial grooves 6 at the  
15 torque transmitting portions come in contact with each other to play the roll of torque transmission, while in the preload portion the elastic member 8 is elastically deformed to restrict the rolling member 7 between the male shaft 1 and the female shaft 2 in  
20 the circumferential direction resulting in preventing backlash and transmitting low torque.

【0047】

For example, when torque is input from the male shaft 1, in early stage since a preload of the  
25 elastic member 8 is applied, backlash is prevented.

【0048】

Upon further increasing the torque, the axially



elongated projection 4 and a side of the axial groove 6 at the torque transmitting portions firmly come in contact with each other, the axially elongated projection 4 receives stronger reactive force than the spherical member 7, and the torque transmitting portions mainly transmit torque. Accordingly, in the present embodiment, backlash between the male shaft 1 and the female shaft 2 in the circumferential direction is securely prevented and torque can be transmitted in a high rigidity state.

[0049]

In the telescopic shaft according to the present embodiment having above-described construction as shown in Fig. 3, when a gap between the axially elongated projection 4 and the axial groove 6 in the torque transmitting portions is converted into a rotation angle A, and a possible flexural amount of the elastic member 8 in the preload portion is converted into a rotation angle B, the rotation angle A is set to be less than the rotation angle B upon transmitting no torque.

[0050]

Moreover, the rotation angle A at the torque transmitting portions is preferably set from 0.01 degrees to 0.25 degrees.

[0051]

With constructing in this manner, upon

transmitting torque, the axially elongated projection 4 and the axial groove 6 composing the torque transmitting portions can become in contact with each other securely earlier than the spherical member 7 and the elastic member 8 which compose the preload portion. Accordingly, it becomes possible to prevent excessive load from applying to the spherical member 7 and the elastic member 8 in the preload portion.

[0052]

It is preferable that the axially elongated projection 4 and the axial groove 6, which are the torque transmitting portions spline-fitted each other, basically do not come in contact with each other upon transmitting no torque.

[0053]

Then, the rotation angle A at the torque transmitting portions is explained with reference to Fig. 4. As described above, the rotation angle A is preferably set from 0.01 degrees to 0.25 degrees.

[0054]

As a reason of the lower limit, an interval between the axially elongated projection 4 and the axial groove 6 which compose the torque transmitting portions is necessary to have a gap capable of allowing them to slide with each other without resistance. A gap having 2 $\mu$ m or more is sufficient. The amount is converted into the rotation angle of

0.01 degrees.

[0055]

As a reason of the upper limit, when an interval between the axially elongated projection 4 and the axial groove 6 which compose the torque transmitting portions is set excessively large, the rotation angle C in Fig. 4 becomes too large. As a result, the preload range by the elastic member 8 becomes large, so that it becomes impossible to obtain a good steering feeling with high degree of rigidity. In this situation, as a result of evaluating various trial models, the upper limit of the rotation angle A of the projection 4 (at one side) is set to 0.25 degrees.

15 [0056]

It is preferable that a point of inflection from the preload range by the elastic member 8 (lower torque range) to the high rigidity range (higher torque range) is  $+2N \cdot m$  or more, or  $-2N \cdot m$  or less. Incidentally, this is derived from in-vehicle sensory test result.

[0057]

In addition to the above-described explanation, each component of the telescopic shaft according to the present embodiment is preferably constructed as shown in Tables 1 and 2 shown blow.

25 [0058]

【Table 1】

PARTS	ITEM	CONTENTS
male shaft (1)	material	C:0.3% or more, Mn:0.3% or more
	hardness	HV120 or more
	roughness, surface treatment	solid lubricant film (MOS2, PTFE, or the like)
	groove shape, processing	cold forming
		broaching
	shaft diameter	13 mm or more
	structure, shape	spline module 0.4 ~ 3
female shaft (2)	material	C: 0.2% or more
	hardness	HV120 or more
	roughness, surface treatment	solid lubricant film (MOS2, PTFE, or the like)
	groove shape, processing	cold forming
		broaching
	structure, shape	spline module 0.4 ~ 3
		ball groove: 2~6 rows
elastic member (8)	material	SK
		S50C~60C
		SUS304
	hardness	HV300~400
	heat treatment	quenching, tempering
	structure, shape	plate thickness:0.1~1 mm
	processing	press forming

【0059】

【Table 2】

PARTS	ITEM	CONTENTS
rolling member (7)	material	SUJ2, ceramic, or the like
	hardness	HV300 or more
	structure,	3~10 pieces/row
	shape	diameter: $\phi$ 3~7 mm
retainer	material	resin
		steel
	structure, shape	integrated
stopper plate (9)	processing	press
	structure, shape	caulking(or clinching)
grease	material	with solid lubricant (MOS2, PTFE, or the like)

Since the axially elongated projection 4 and the  
 5 axial groove 6 receive load with continuously coming  
 in contact with each other in the axial direction  
 upon transmitting torque, various merits can be  
 expected such as the contact pressure can be  
 suppressed lower than that in the rolling member 7  
 10 which receives load with point contact. Accordingly,  
 the present embodiment is superior to the  
 conventional one which uses ball rolling mechanism in  
 all rows in the following items:

•Attenuation effect in the sliding portion is  
 15 larger than that in the ball rolling mechanism.

Accordingly, vibration absorption effect is high.

·Since the contact pressure can be lower in the axially elongated projection 4 upon transmitting the same torque, the axial length of the torque transmitting portions can be smaller, so that the space can be used effectively.

·Since the contact pressure can lower in the axially elongated projection 4 upon transmitting the same torque, it is not necessary to carry out additional processing for hardening the surface of the axial groove of the female shaft such as thermal treatment and the like.

·The number of parts can be small.

·Assembling can be easy.

·Assembling cost can be lowered.

·Since torque transmission is mainly carried out by the torque transmitting portions, the number of the rolling member 7 can be small, and a collapse stroke can be made large.

[0060]

Moreover, in respect of partially applying the rolling member 7, the present embodiment is superior in the following items to the conventional one that all rows are spline-fitted and all rows are slid:

·Since friction force is low, a sliding load can be suppressed.

·Since preload can be high, backlash can be

prevented for long period and high rigidity can be obtained.

[0061]

(VARIATIONS OF THE FIRST EMBODIMENT)

5        Fig. 5(a) is a cross-sectional view showing a telescopic shaft for vehicle steering according to a first variation of the first embodiment of the present invention. Fig. 5(b) is a cross-sectional view showing a telescopic shaft for vehicle steering  
10       according to a second variation of the first embodiment of the present invention.

[0062]

15       Fig. 6(a) is a cross-sectional view showing a telescopic shaft for vehicle steering according to a third variation of the first embodiment of the present invention. Fig. 6(b) is a cross-sectional view showing a telescopic shaft for vehicle steering according to a fourth variation of the first  
20       embodiment of the present invention.

[0063]

25       Fig. 7(a) is a cross-sectional view showing a telescopic shaft for vehicle steering according to a fifth variation of the first embodiment of the present invention. Fig. 7(b) is a cross-sectional view showing a telescopic shaft for vehicle steering according to a sixth variation of the first  
embodiment of the present invention.

[0064]

Fig. 8 is a cross-sectional view showing a telescopic shaft for vehicle steering according to a seventh variation of the first embodiment of the present invention.

[0065]

In all of the following variations, each of the similar construction to the first embodiment is attached to the same reference number, and the explanation thereof is omitted.

[0066]

In a telescopic shaft for vehicle steering composed of a male shaft 1 and a female shaft 2, which are spline fitted each other, according to the first variation shown in Fig. 5(a), similar preload portions as the first embodiment are disposed between the male shaft 1 and the female shaft 2 with 180 degrees intervals in the circumferential direction. A plurality of torque transmitting portions (axially elongated projections 4 and axial grooves 6) each of which is spline fitted as same as the first embodiment are disposed in each interval between the preload portions. The other configurations, actions and effects are the same as those of the first embodiment, and the explanations are omitted.

[0067]

In a telescopic shaft for vehicle steering



composed of a male shaft 1 and a female shaft 2,  
which are spline fitted each other, according to a  
second variation shown in Fig. 5(b), similar preload  
portions as the first embodiment are disposed between  
5 the male shaft 1 and the female shaft 2 with an 120  
degrees interval in the circumferential direction. A  
plurality of torque transmitting portions (axially  
elongated projections 4 and axial grooves 6) each of  
which is spline fitted as same as the first  
10 embodiment are disposed in each interval between the  
preload portions. By disposing the preload portions  
with a 120 degrees interval in the circumferential  
direction, decentering of the shaft can be improved  
relative to the first variation, so that right and  
15 left difference in torsional rigidity upon loading  
high torque as well as right and left difference in a  
total sliding load upon loading high torque can be  
reduced. The other configurations, actions and  
effects are the same as those of the first embodiment,  
20 and the explanations are omitted.

[0068]

A third variation shown in Fig. 6(a) and a  
fourth variation shown in Fig. 6(b) have a  
characteristic feature of forming a solid lubricant  
25 film 11 on the outer surface of the male shaft 1  
relative to the first and second variations shown in  
Figs. 5(a)(b). In this manner, by forming a solid

lubricant film 11 on the outer surface of the male shaft 1, contact resistance between the axially elongated projection 4 and the axial groove 6 in the torque transmitting portions can be lowered, so that the total sliding load (which is a sliding load generated in ordinary use in the construction according to the present invention in which both rolling and sliding are acting) can be lowered in comparison with the first embodiment, and the first and second variations. As for a solid lubricant film, there are used films formed such that molybdenum disulfide powder is dispersively mixed in resin, the mixture is applied by spray coating or dip coating, and baked to form the film, or PTFE (polytetrafluoroethylene) is dispersively mixed in resin, the mixture is applied by spray coating or dip coating, and baked to form the film. Alternatively, instead of the solid lubricant film, resin may be coated.

20           [0069]

A fifth variation shown in Fig. 7(a) and a sixth variation shown in Fig. 7(b) have a characteristic feature of forming a solid lubricant film 11 on the inner surface of the female shaft 2 relative to the first and second variations shown in Figs. 5(a)(b). In this manner, by forming a solid lubricant film 11 on the inner surface of the female shaft 2, contact

resistance between the axially elongated projection 4 and the axial groove 6 at the torque transmitting portions can be lowered, so that the total sliding load (which is a sliding load generated in ordinary use in the construction according to the present invention in which both rolling and sliding are acting) can be lowered in comparison with the first embodiment. As for a solid lubricant film, there are used films formed such that molybdenum disulfide powder is dispersively mixed in resin, the mixture is applied by spray coating or dip coating, and baked to form the film, or PTFE (polytetrafluoroethylene) is dispersively mixed in resin, the mixture is applied by spray coating or dip coating, and baked to form the film.

[0070]

In a seventh variation shown in Fig. 8, a shape of an elastic member at a preload portion is different from that in the first embodiment. In particular, the shape of an elastic member at the preload portion is different from that in the first variation shown in Fig. 5(b). The other configurations, actions and effects are the same as those of the first embodiment. Upon transmitting no torque, the elastic member 8 preloads the rolling member 7 against the female shaft 2 to the extent of having no backlash, and upon transmitting torque, the

elastic member 8 elastically deforms to restrict the spherical member 7 in the circumferential direction between the male shaft 1 and the female shaft 2. The elastic member 8 is fixed to ridges 3c disposed both sides of the axial groove 3 on the male shaft 1 by means of groove portions 8e disposed both ends thereof. With this configuration, the elastic member 8 cannot be moved in the circumferential direction upon transmitting torque.

10           [0071]

In the aforementioned first through seventh variations, a further lower sliding load can be obtained by applying grease on the sliding surface and rolling surface. When the axially elongated projection 4 formed on the male shaft is formed on the female shaft, or the axial groove 6 formed on the female shaft is formed on the male shaft, the similar action and effect as the present embodiment can be obtained. The curvature of the axial groove 5 and that of the rolling member 7 may be different from to come into point contact with each other. The rolling member 7 may be a spherical member. The elastic member 8 may be a leaf spring.

          [0072]

25           (SECOND EMBODIMENT)

Fig. 9 is a cross-sectional view showing a telescopic shaft for vehicle steering according to a

second embodiment of the present invention.

[0073]

In the second embodiment, each of the similar construction to the first embodiment is attached to the same reference number, and the explanation is  
5 omitted.

[0074]

In the second embodiment, three axially elongated projections 4 each having a substantially arc sectional shape are formed in the axial direction  
10 on the outer surface of the male shaft 1 with an equal interval of 120 degrees in the circumferential direction. Three axial grooves 6 each having a substantially arc sectional shape are formed in the  
15 axial direction on the inner surface of the female shaft 2 at the portions opposite to the three axially elongated projections 4 on the male shaft.

[0075]

The axially elongated projection 4 and the axial  
20 groove 6 basically do not come in contact with each other upon transmitting no torque, however, come in contact with each other forming torque transmitting portions upon transmitting high torque.

[0076]

25 The axially elongated projection 4 and the axial groove 6 have a substantially arc shape or a Gothic arch shape in section, however, other shapes may be

applicable.

[0077]

In the present embodiment also, when a gap  
between the axially elongated projection 4 and the  
5 axial groove 6 in the torque transmitting portions is  
converted into a rotation angle A, and a possible  
flexural amount of the elastic member 8 in the  
preload portion is converted into a rotation angle B,  
the rotation angle A is set to be less than the  
10 rotation angle B upon transmitting no torque.

Moreover, the rotation angle A in the torque  
transmitting portions is preferably set from 0.01  
degrees to 0.25 degrees.

[0078]

15 With constructing in this manner, upon  
transmitting torque, the torque transmitting portions  
(the axially elongated projection 4 and the axial  
groove 6) can prevent backlash and come in contact  
with each other securely earlier than the preload  
20 portion (the spherical member 7 and the elastic  
member 8) which transmits lower torque. Accordingly,  
it becomes possible to prevent excessive load from  
applying to the preload portion (the rolling member 7  
and the elastic member 8). It is preferable that the  
25 torque transmitting portions (the axially elongated  
projection 4 and the axial groove 6), which are  
spline-fitted each other, basically do not come in

contact with each other upon transmitting no torque.

[0079]

(VARIATIONS IN SECOND EMBODIMENT)

Fig. 10 is a cross-sectional view showing a  
5 telescopic shaft for vehicle steering according to a  
first variation of the second embodiment of the  
present invention.

[0080]

Fig. 11 is a cross-sectional view showing a  
10 telescopic shaft for vehicle steering according to a  
second variation of the second embodiment of the  
present invention.

[0081]

Fig. 12(a) is a vertical cross-sectional view  
15 showing a telescopic shaft for vehicle steering  
according to a third variation of the second  
embodiment of the present invention. Fig. 12(b) is a  
cross-sectional view along a b-b line in Fig. 12(a).

[0082]

20 In all of the following variations, each of the  
similar constructions to the first or second  
embodiment is attached to the same reference number,  
and the explanation thereof is omitted.

[0083]

25 The first variation shown in Fig. 10 has a  
characteristic feature of forming a solid lubricant  
film 11 on the outer surface of the male shaft 1

relative to the second embodiment. In this manner, by forming a solid lubricant film 11 on the outer surface of the male shaft 1, contact resistance between the axially elongated projection 4 and the axial groove 6 in the torque transmitting portions can be lowered, so that the total sliding load (which is a sliding load generated in ordinary use in the construction according to the present invention in which both rolling and sliding are acting) can be lowered in comparison with the first embodiment. As for a solid lubricant film 11, there are used films formed such that molybdenum disulfide powder is dispersively mixed in resin, the mixture is applied by spray coating or dip coating, and baked to form the film, or PTFE (polytetrafluoroethylene) is dispersively mixed in resin, the mixture is applied by spray coating or dip coating, and baked to form the film. Alternatively, instead of the solid lubricant film, resin may be coated. Although the solid lubricant film 11 is formed over entire outer surface of the male shaft 1, it may be formed only on the outer surface of the axially elongated projections 4 disposed at three positions on the male shaft 1. This is because the primary factor of the sliding load upon transmitting high torque is contact between the axially elongated projection 4 and the axial groove 6, so that the axial sliding resistance



can be lowered by lowering the contact resistance in the contact position.

[0084]

The second variation shown in Fig. 11 has a  
5 characteristic feature of forming a solid lubricant film 11 on the inner surface of the female shaft 2 relative to the second embodiment. In this manner, by forming a solid lubricant film 11 on the inner  
10 surface of the female shaft 2, contact resistance between the axially elongated projection 4 and the axial groove 6 in the torque transmitting portions can be lowered, so that the total sliding load (which is a sliding load generated in ordinary use in the construction according to the present invention in  
15 which both rolling and sliding are acting) can be lowered in comparison with the first embodiment. As for a solid lubricant film 11, there are used films formed such that molybdenum disulfide powder is dispersively mixed in resin, the mixture is applied  
20 by spray coating or dip coating, and baked to form the film, or PTFE (polytetrafluoroethylene) is dispersively mixed in resin, the mixture is applied by spray coating or dip coating, and baked to form the film. Although the solid lubricant film 11 is  
25 formed over entire inner surface of the female shaft 2, it may be formed only on the inner surface of the axial grooves 6 disposed at three positions on the

female shaft 2. This is because the primary factor of the sliding load upon transmitting high torque is contact between the axially elongated projection 4 and the axial groove 6, so that the axial sliding resistance can be lowered by lowering the contact resistance in the contact portion.

[0085]

In a third variation shown in Fig. 12, a shape of an elastic member in a preload portion is different from that in the above-described second embodiment. Upon transmitting no torque, the elastic member 8 preloads the spherical member 7 against the female shaft 2 to the extent of having no backlash, and upon transmitting torque, the elastic member 8 elastically deforms to restrict the spherical member 7 in the circumferential direction between the male shaft 1 and the female shaft 2. The elastic member 8 is fixed to ridges 3c disposed both sides of the axial groove 3 on the male shaft 1 by means of groove portions 8e disposed both ends thereof. With this configuration, the elastic member 8 cannot be moved in the circumferential direction upon transmitting torque. In a third variation shown in Fig. 12, a retainer 20 for rotatably retaining the ball 7 without interfering with the axially elongated projection 4, is disposed between the male shaft 1 and the female shaft 2. The other configurations are

the same as the above-described second embodiment.  
The retainer 20 has a cylindrical shape disposed with  
an elongate hole 21 for rotatably holding the ball 7  
and an interference avoiding elongate hole 22 that is  
5 disposed at a position opposite to the axially  
elongated projection 4 and avoids interference with  
the axially elongated projection 4. The interference  
avoiding elongate hole 22 is formed conspicuously  
longer than the elongate hole 21 in the axial  
10 direction. With this configuration, although both of  
the ball 7 and the axially elongated projection 4 are  
there in the same axial section, the present  
embodiment makes it possible to hold the balls 7, so  
that sliding function can be improved (stabilizing  
15 the sliding load). As a result, pleasant steering  
feeling can be obtained.

[0086]

In the aforementioned second embodiment and the  
first through third variations, a further lower  
20 sliding load can be obtained by applying grease on  
the sliding surface and rolling surface. It may be  
possible that the curvature of the axially elongated  
projection 4 is made to be different from that of the  
axial groove 6 so that the axially elongated  
25 projection 4 and the axial groove 6 come into linear  
contact with each other. When the axially elongated  
projection 4 formed on the male shaft is formed on

the female shaft, or the axial groove 6 formed on the female shaft is formed on the male shaft, the similar action and effect as the present embodiment can be obtained. It may be possible that the curvature of the axial groove 5 is made to be different from that of the rolling member 7 to come into point contact with each other.

[0087]

(OTHER RELATED MATTERS)

10 In all of the embodiments of the present invention, the solid male shaft may be replaced with a hollow shaft. Moreover, in all of the embodiments of the present invention, the followings may be said: The male shaft may be indiscerptible structure by  
15 plastically deforming the end portion thereof inward to prevent the male shaft from being extracted. The rolling member 7 may a heat-treated one, and it may be a polished one. The outer surface of the male shaft 1 may be processed with a resin coating  
20 including PTFE (polytetrafluoroethylene) or molybdenum disulfide. The male shaft 1 may be made of a solid or hollow steel material fabricated by cold pultrusion. The male shaft 1 may be made of an aluminum material fabricated by cold extrusion. The  
25 male shaft 1 may be made of a solid steel or aluminum material fabricated by cold forging. The female shaft 2 may be made of a hollow steel material fabricated

by cold pultrusion molding. When the male shaft is fabricated by cold forging, the material is preferably carried out metallic soap treatment (bonderizing). The female shaft may be made of a hollow steel, and after carrying out metallic soap treatment (bonderizing), the material may be carried out reducing or extending process to the required diameter with forming groove portions by press forming. The female shaft 2 may be nitrided. The inner surface of the female shaft 2 may be treated with resin coating including PTFE (polytetrafluoroethylene) or molybdenum disulfide [0088]

In all of the embodiments of the present invention, it is preferable that the following numerical ranges are used:

- Contact pressure of the rolling member is 1500Mpa or less upon loading no torque.
- Contact pressure of the rolling member is 2000Mpa or less upon loading torque of 100Nm.
- Contact pressure of the axially elongated projection is 2000Mpa or less upon loading torque of 100Nm.

[0089]

With comparing conventional products, the present invention is summarized as follows:

- It is low cost.

- It can obtain a stable, low sliding load.
- It has no backlash.
- It is superior to wear resistance
- It is superior to heat resistance.
- 5     •It can be made to be light weight.
- It is a small mechanism.
- It can cope with any using condition without  
changing design concept.

[0090]

10       In Japanese Patent Application Laid-Open No.  
2001-50293 and German Patent Application Laid-Open DE  
3730393 A1, there is disclosed a mechanism that a  
plurality of rolling members are disposed in axial  
grooves formed on a male shaft and a female shaft and  
15     are preloaded by an elastic member. In comparison  
with this, the present invention, as described above,  
is far superior to the case where the whole rows are  
ball rolling mechanism or the case where a  
conventional spline-fitted mechanism is used.

20       [0091]

      In European Patent Application Laid-Open  
EP1078843A1, there is disclosed a mechanism that  
prevents backlash by being composed of needle rollers,  
a retainer thereof, and a regulator for removing  
25     backlash. However, the regulator is a simple sliding  
mechanism, so that the preload cannot be large.  
Accordingly, it becomes extremely difficult to

prevent backlash or obtain high rigidity for long period.

[0092]

On the contrary, as described above, the present invention is extremely superior in such manner that since a rolling mechanism is partially used and the way to prevent backlash is also different, the frictional resistance is low, so that the sliding load can be low, and the preload can be high, so that backlash can be prevented and high rigidity can be obtained for long period.

[0093]

The present invention is not limited to the above-described embodiments and is possible to apply to various variations.

[Brief Description of the Drawings]

[0094]

[Fig. 1]

Fig. 1 is a side view showing a steering mechanism of a vehicle applied a telescopic shaft for vehicle steering according to an embodiment of the present invention.

[Fig. 2]

Fig. 2 is a vertical cross-sectional view showing a telescopic shaft for vehicle steering according to a first embodiment of the present invention.

[Fig. 3]

Fig. 3 is a partial sectional view along a III-III line in Fig. 2.

[Fig. 4]

5        Fig. 4 is a graph showing a relation between torque and a rotation angle of the telescopic shaft for vehicle steering according to the first embodiment of the present invention.

[Fig. 5]

10        Fig. 5(a) is a cross-sectional view showing a telescopic shaft for vehicle steering according to a first variation of the first embodiment of the present invention. Fig. 5(b) is a cross-sectional view showing a telescopic shaft for vehicle steering  
15        according to a second variation of the first embodiment of the present invention.

[Fig. 6]

Fig. 6(a) is a cross-sectional view showing a telescopic shaft for vehicle steering according to a  
20        third variation of the first embodiment of the present invention. Fig. 6(b) is a cross-sectional view showing a telescopic shaft for vehicle steering according to a fourth variation of the first embodiment of the present invention.

25        [Fig. 7]

Fig. 7(a) is a cross-sectional view showing a telescopic shaft for vehicle steering according to a



fifth variation of the first embodiment of the present invention. Fig. 7(b) is a cross-sectional view showing a telescopic shaft for vehicle steering according to a sixth variation of the first  
5 embodiment of the present invention.

[Fig. 8]

Fig. 8 is a cross-sectional view showing a telescopic shaft for vehicle steering according to a seventh variation of the first embodiment of the  
10 present invention.

[Fig. 9]

Fig. 9 is a cross-sectional view showing a telescopic shaft for vehicle steering according to a second embodiment of the present invention.

15 [Fig. 10]

Fig. 10 is a cross-sectional view showing a telescopic shaft for vehicle steering according to a first variation of the second embodiment of the present invention.

20 [Fig. 11]

Fig. 11 is a cross-sectional view showing a telescopic shaft for vehicle steering according to a second variation of the second embodiment of the present invention.

25 [Fig. 12]

Fig. 12(a) is a vertical cross-sectional view showing a telescopic shaft for vehicle steering

according to a third variation of the second embodiment of the present invention. Fig. 12(b) is a cross-sectional view along a b-b line in Fig. 12(a).

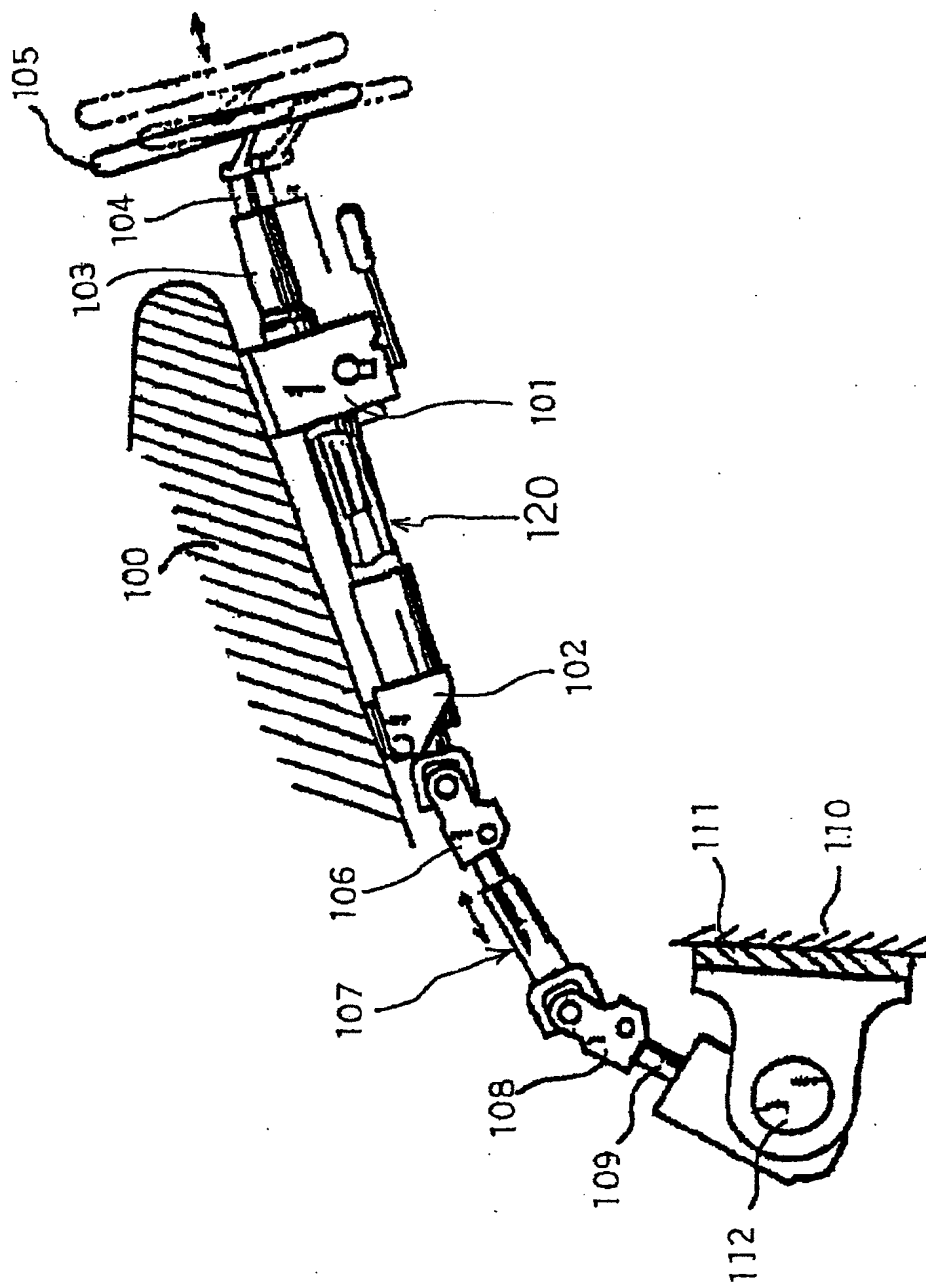
[Description of Reference Numerals or Symbols]

5	[0095]
	1 male shaft
	2 female shaft
	3 axial groove
	3a planner side
10	3b bottom
	3c ridge
	4 axially elongated projection
	5 axial groove
	6 axial groove
15	7 spherical member (ball, rolling member)
	8 elastic member
	8a spherical member side contact portion (transmitting member side contact portion)
	8b groove side contact portion
20	8c spring portion
	8d bottom portion
	8e groove portion
	9 stopper plate
	10 caulking portion
25	11 solid lubricant film
	20 retainer
	21 elongate hole

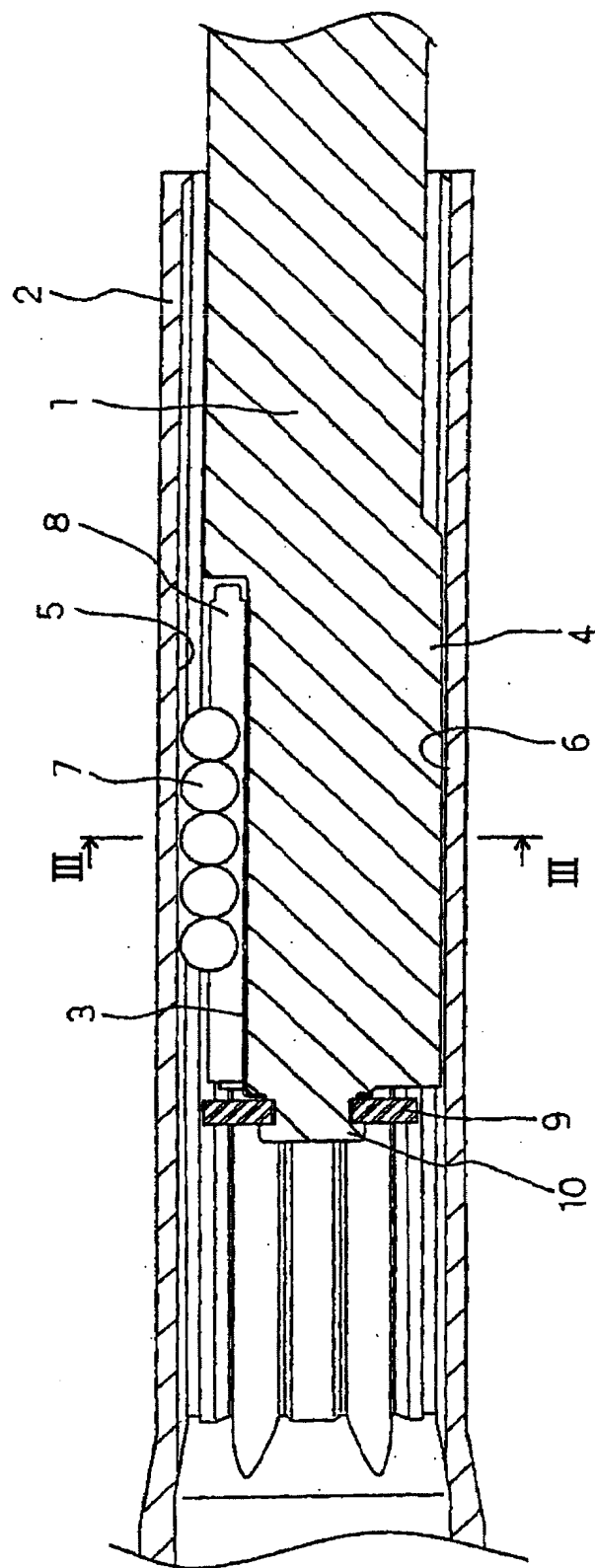
	22	interference avoiding elongate hole
	100	member
	101	upper bracket
	102	lower bracket
5	103	steering column
	104	steering shaft
	105	steering wheel
	106	universal joint
	107	lower steering shaft portion
10	108	steering shaft joint
	109	pinion shaft
	110	frame
	111	elastic member
	112	steering rack
15	120	upper steering shaft portion

【書類名】 図面 [Name of the document] Drawings

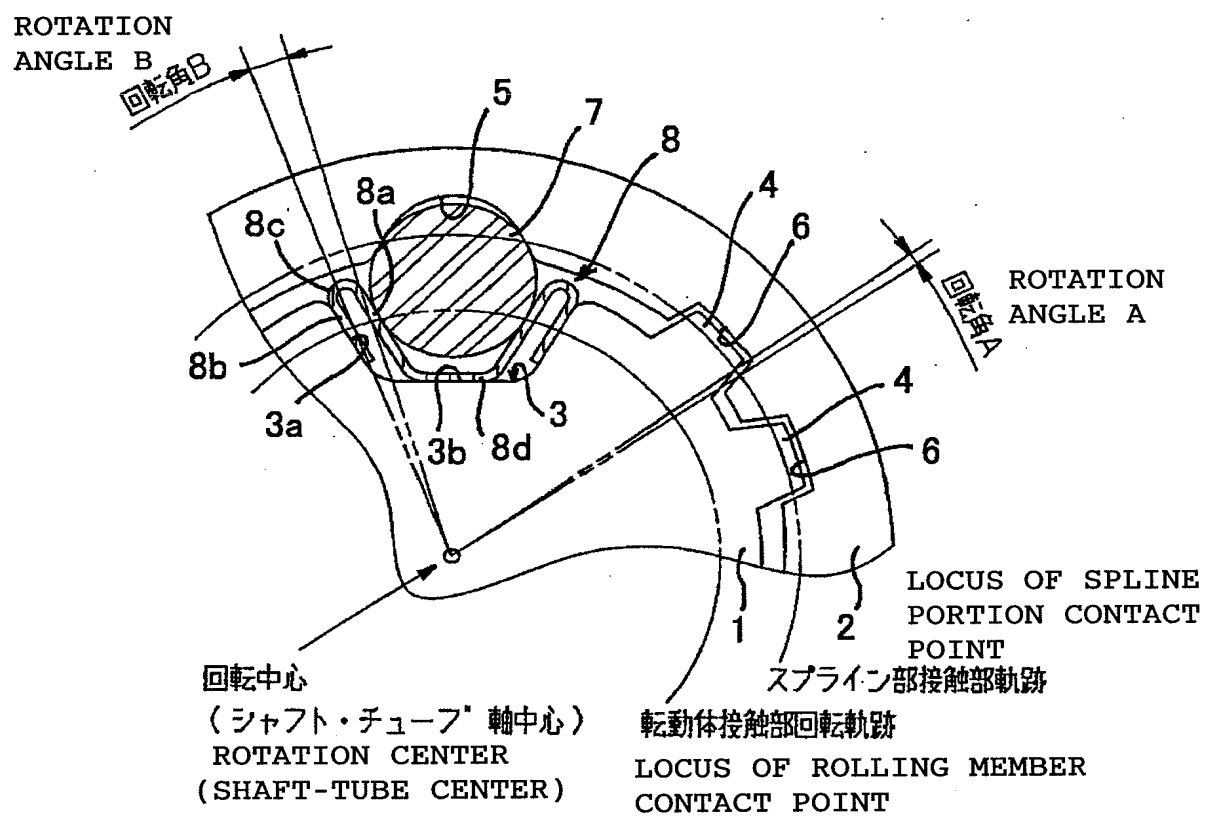
【図1】 [FIG. 1]



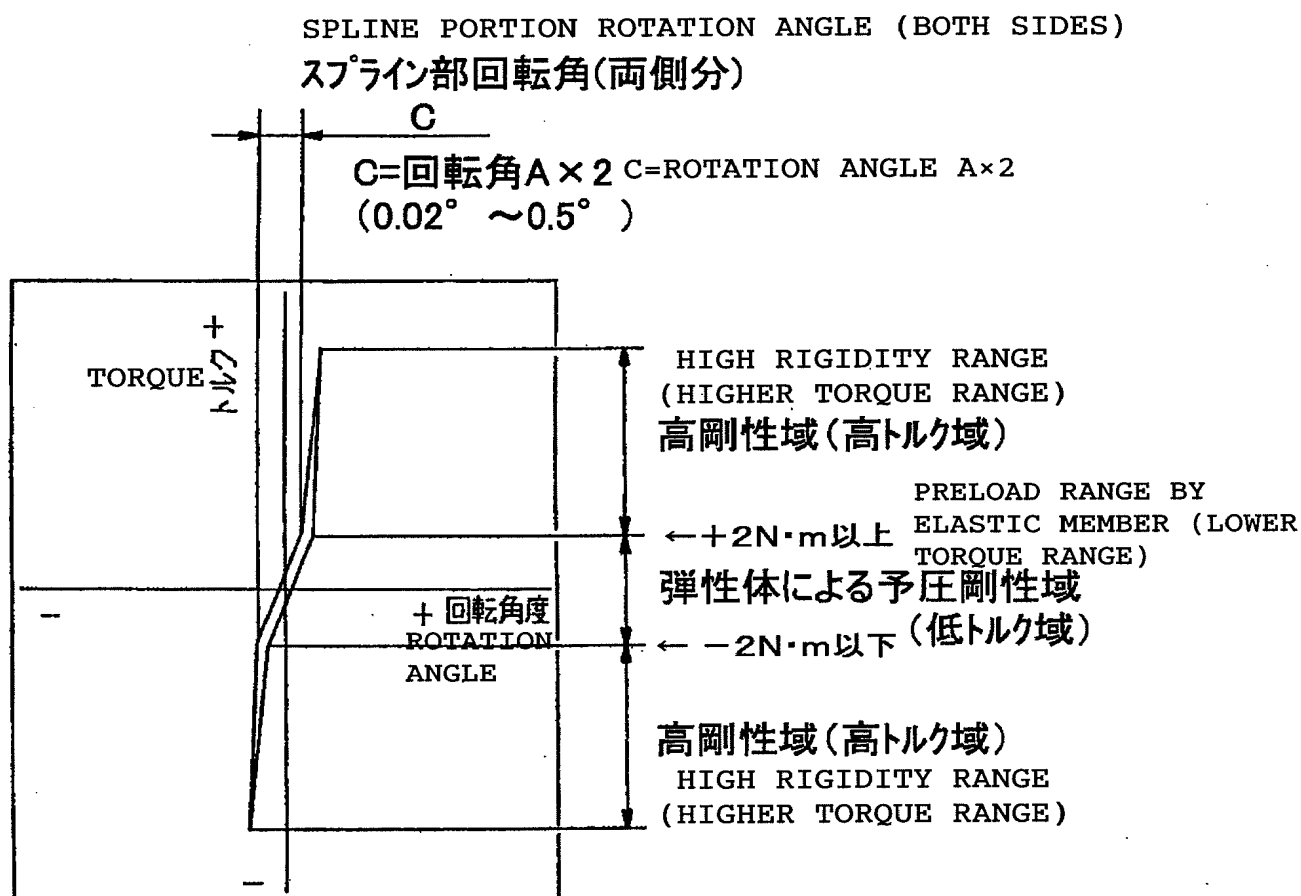
【図2】 [FIG. 2]



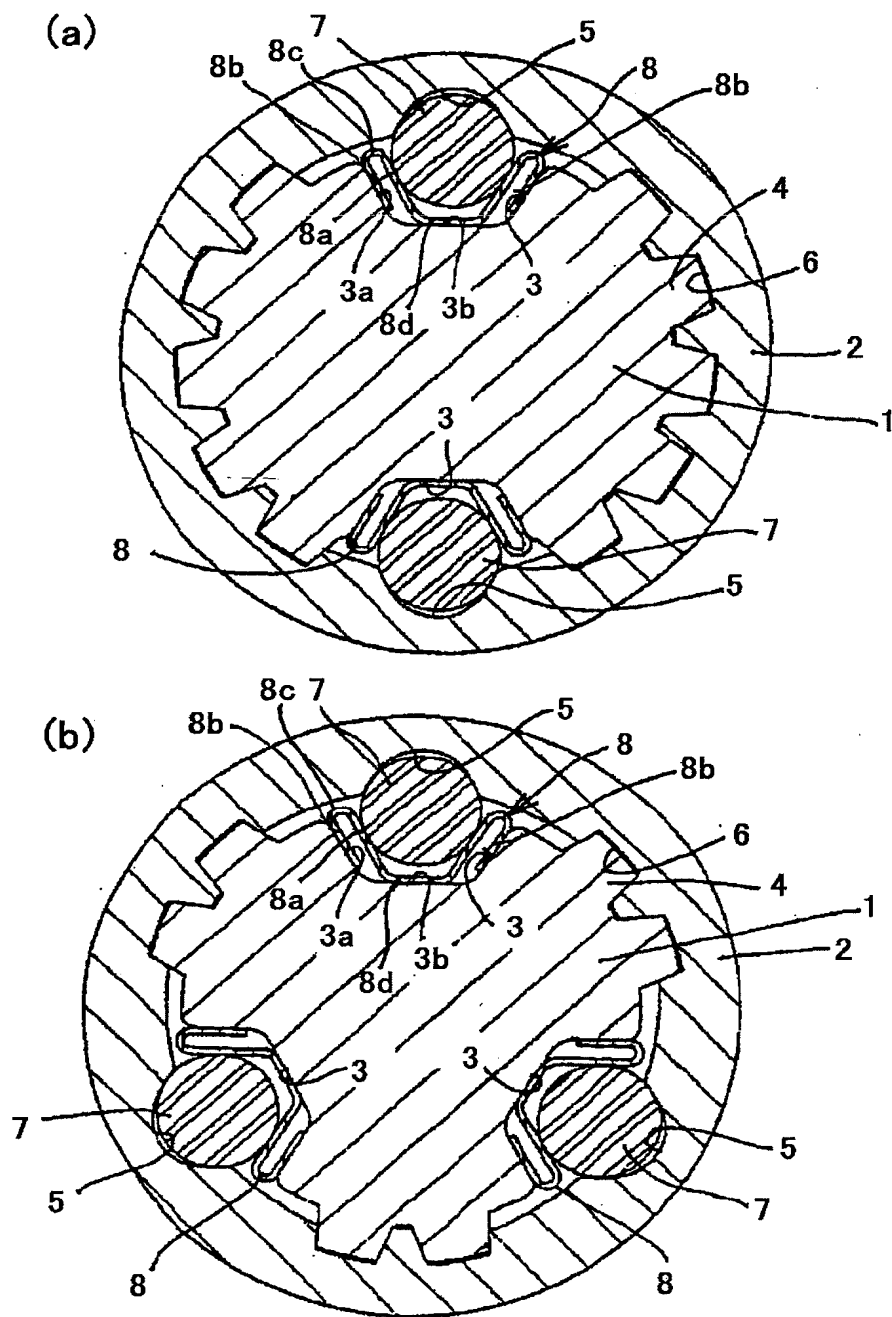
【図3】[FIG. 3]



【図4】[FIG. 4]

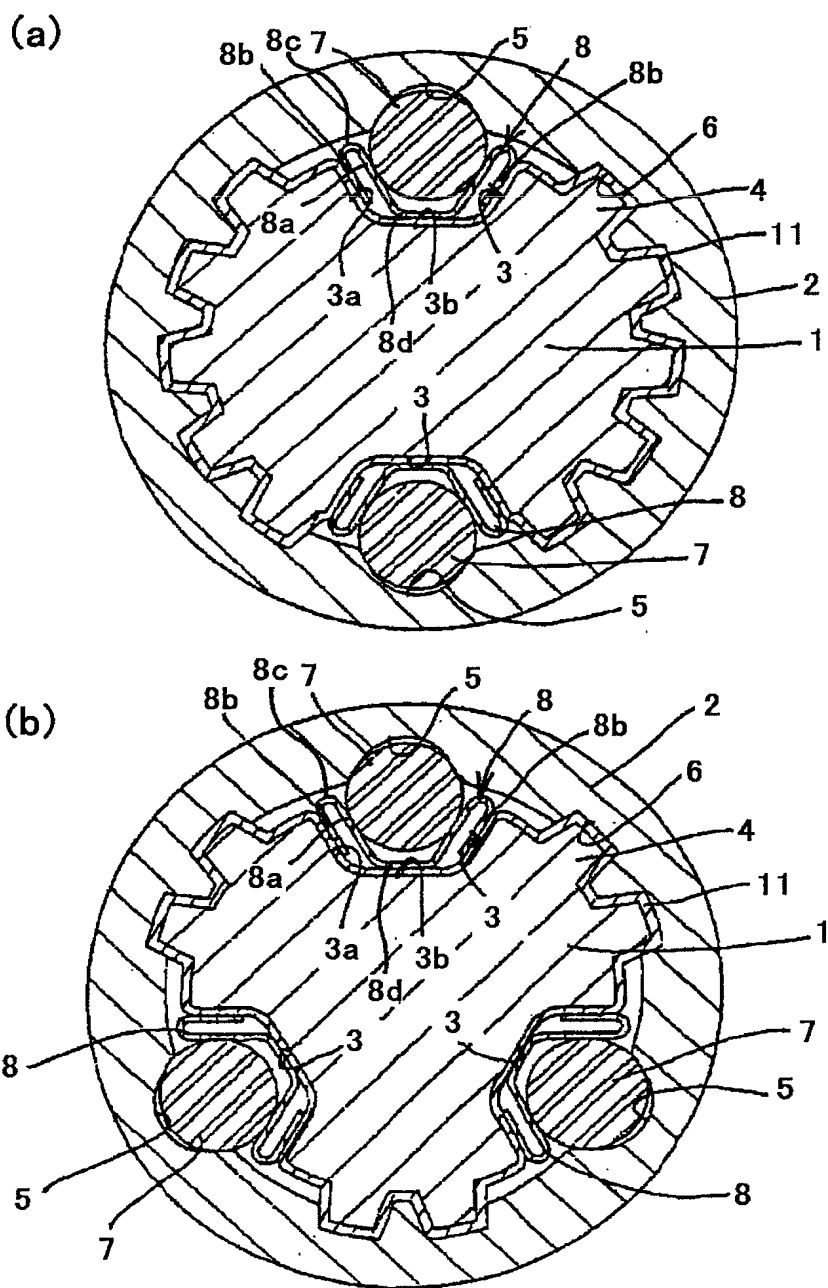


【図5】[FIG. 5]

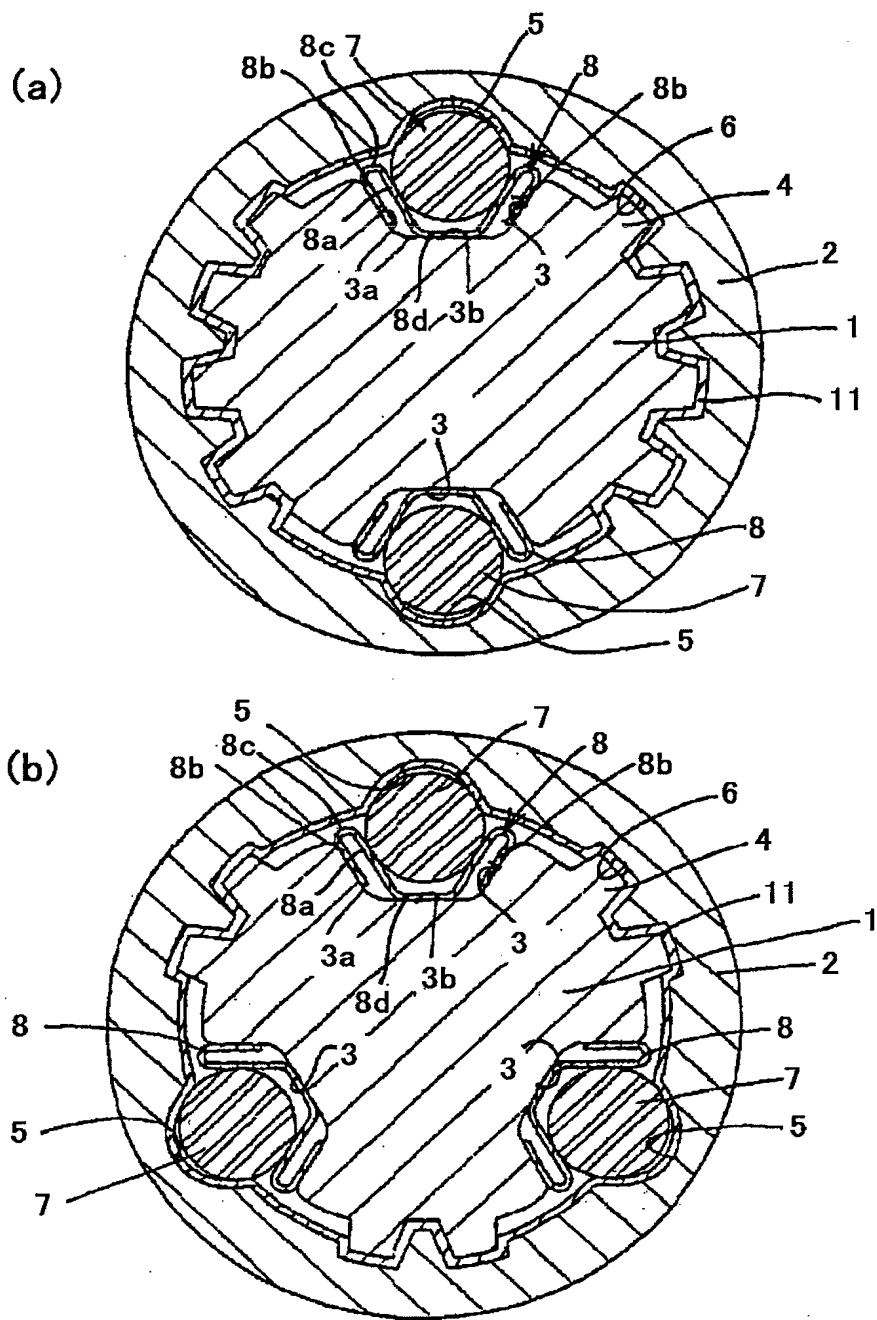




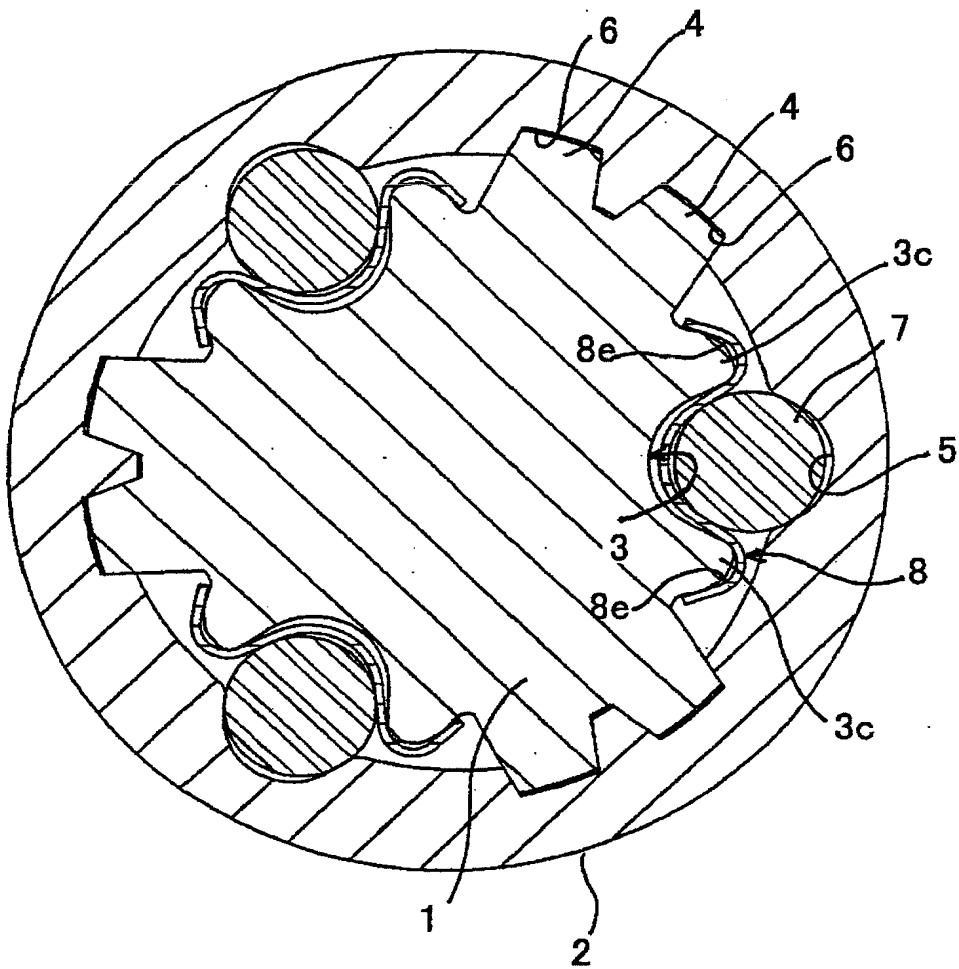
【図6】[FIG. 6]

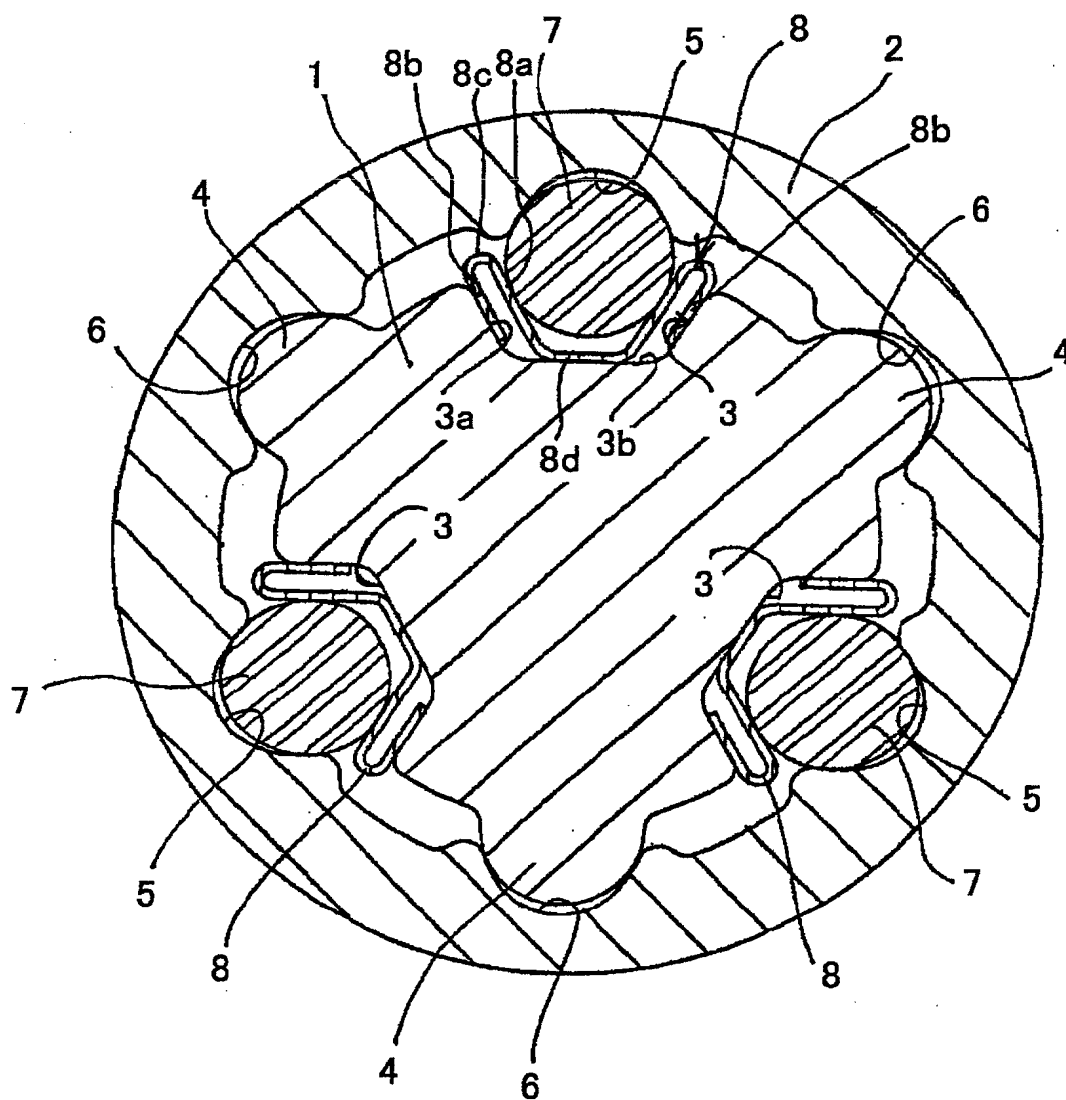


【図7】[FIG. 7]

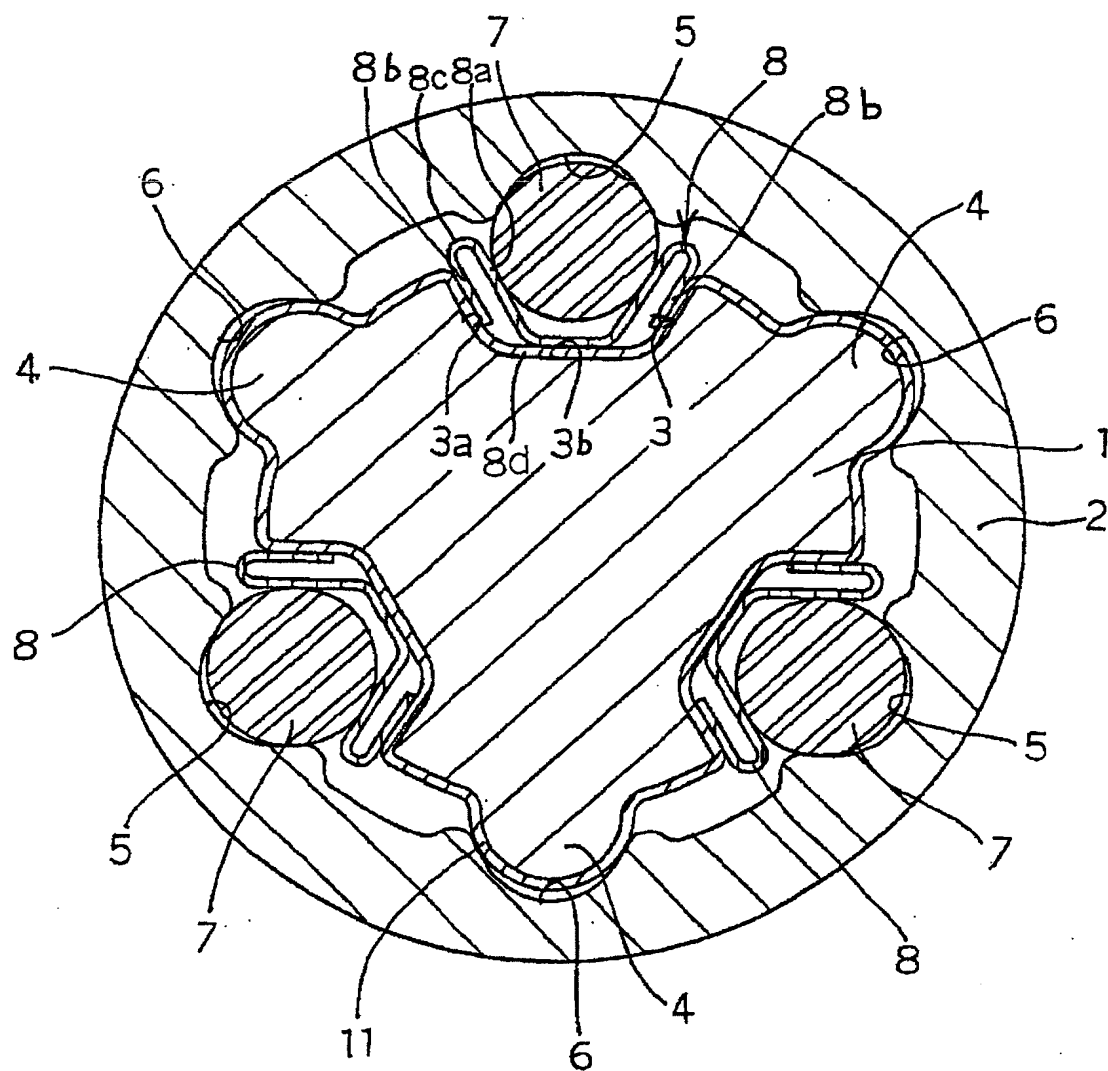


【図8】[FIG. 8]

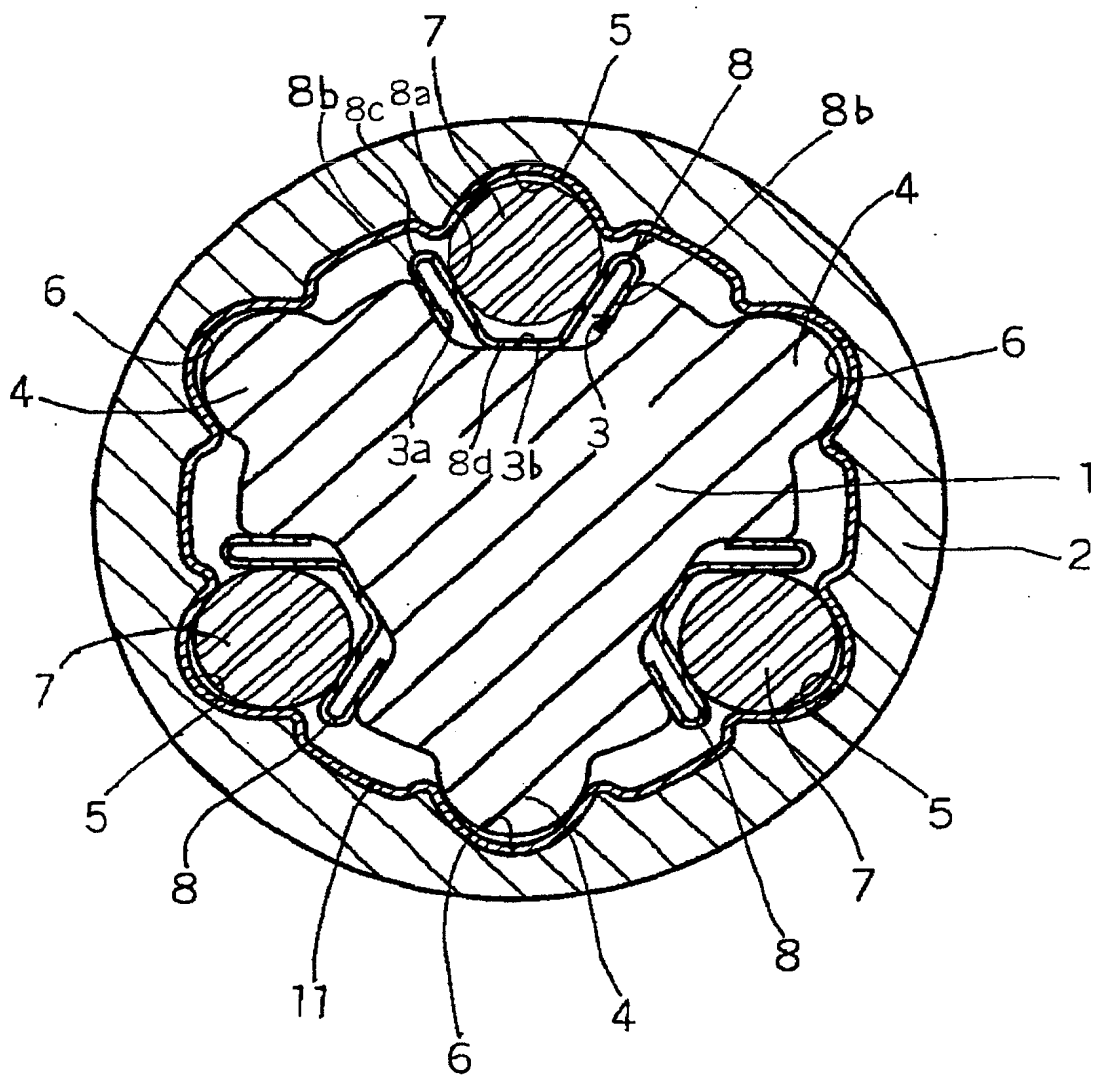




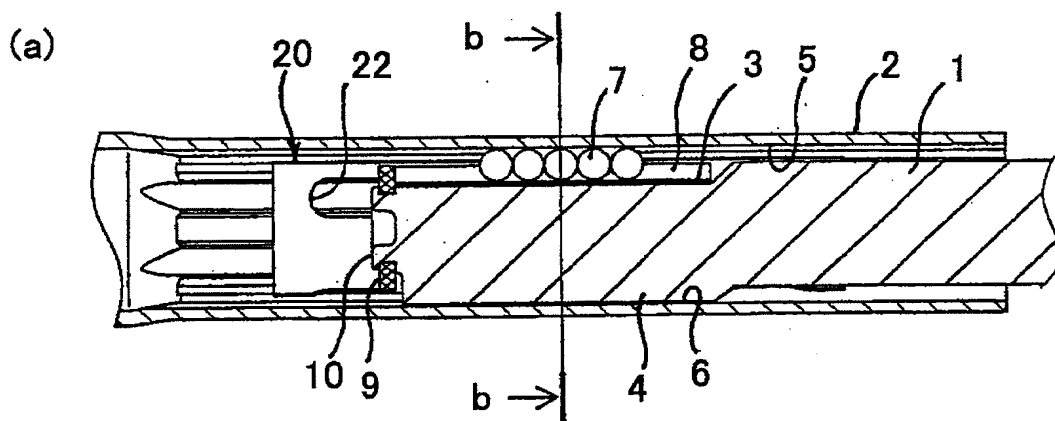
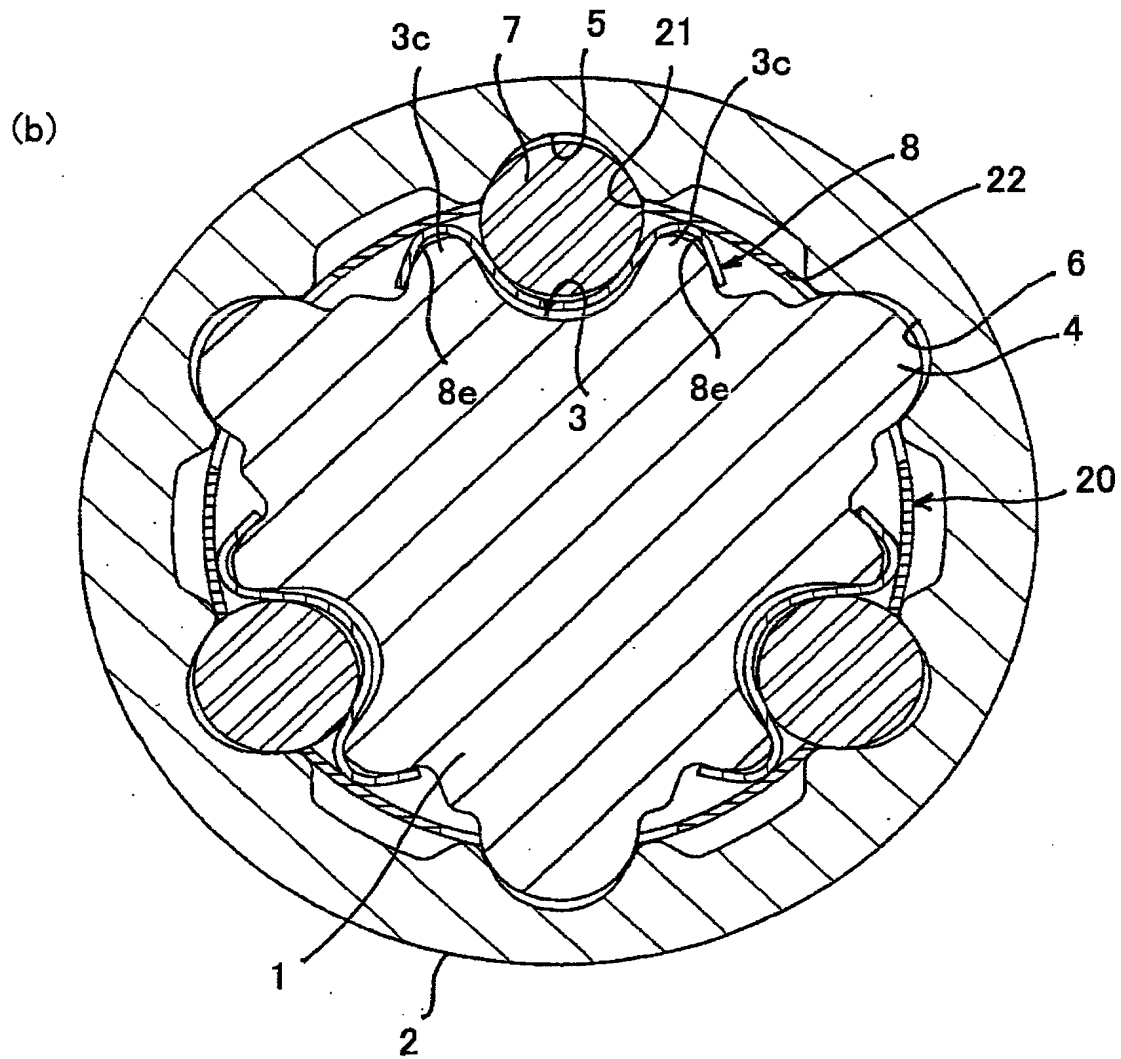
【図10】[FIG. 10]



【図11】[FIG. 11]



【図12】[FIG. 12]



5            [Name of the Document]            Abstract

            [Abstract]

            [Object]

            To realize a stable sliding load and to transmit  
5     torque under high rigidity with securely preventing  
            backlash in the rotational direction.

            [Means for Achieving the Object]

            When a gap between an axially elongated  
            projection 4 and an axial groove 6 in the torque  
10     transmitting portions is converted into a rotation  
            angle A and a possible flexural amount of an elastic  
            member 8 in the preload portion is converted into a  
            rotation angle B, the rotation angle A is set to be  
            less than the rotation angle B upon transmitting no  
15     torque. Accordingly, upon transmitting torque, the  
            torque transmitting portions (the axially elongated  
            projection 4 and the axial groove 6) which transmit  
            torque mainly, can become in contact with each other  
            securely earlier than the preload portion (a  
20     spherical member 7 and the elastic member 8), thereby  
            it becoming possible to prevent excessive load from  
            applying to the preload portion (the spherical member  
            7 and the elastic member 8).

            [Elected Drawing]            FIGURE 3